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ANALYSIS OF FACTOR INFLUENCING NET ZERO ENERGY BUILDING CONSTRUCTION BY RII METHOD

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ABSTRACT

Current energy system and the Sustainable environment around the world have turned out to be significant issues of recent decades. More than 1.2 billion sq.m of new commercial floor space, which is about twice of what exists at present, will be included in India throughout the next 20 years. This will lead to a further straining on electricity demand. To take care of this problem, one of the two arrangement must be preserved within the building: either lessen building energy use or use renewable sources of energy as substitutions to fossil fuel energy. The present study on identification of factors influencing net zero energy building (NZEB) in the construction sector in the Indian context. Total 41 factors were identified under 9 major groups. The finding of this paper can be used as a reference by engineers, project managers, architect and contractor in developing their net zero vitality productive structures.

KEYWORDS: Energy Efficient Building, Factor Influencing NZEB, Relative Important Index.

I. INTRODUCTION

The twenty-first century is shaping up to be a transitional era in the way mankind harps on this earth. The pressure we are putting on the planet's assets has turned out to be progressively unsustainable. The subsequent issues we face, for example, water and asset shortage, expanding vitality requests and costs, contracting non-renewable energy source saves, and an evolving atmosphere, have sounded a wake-up call received around the world. (Barrett,2014)

Those who are heeding the call and embracing the need for change are finding the essential arrangements, opportunities not exclusively, to address this global set of problems, yet to progress and enhance mankind's association with the living scene, and enhance our personal satisfaction. Much of the stress we impose on the earth is manifested in the way we design, construct, and use our built environments; that means buildings and cities must play a vital role in shaping our sustainable future. (Vora,2017)

Buildings consume approximately 30-40% of the world's primary energy use. Considering the aggregate energy utilization all through the entire life cycle of a building, the energy execution and supply is a vital issue with regards to environmental change, shortage of vital assets and a decrease in worldwide energy utilization. (Srinivasan,2011)

Net zero energy tools in shaping this future. Construction sector themselves offers significant natural, social, and monetary esteem. These reasons are sufficient to consider a new approach to the use of energy in the construction sector. The initial step would be creating low-energy buildings based on the ideas of energy saving and energy efficiency. Furthermore, concentrating on reducing the impact of buildings on the environment, renewable technologies would come into the concept, mitigating CO2 emissions. Net zero energy offer a convincing vision for the future, a vision that can be viewed as another direction in this construction sector consequently contribute less overall ozone harming substance to the environment than comparative non-NZE buildings. (Athienitis,2008) (Delisle,2011) (Thomos,2013)

Construction of NZE building composed of many interrelated elements, making it difficult to discern which factors were the principle for developing NZEB. In this research, these factors are identified and their significance and contribution to the project measured. The objective of this research is to identify and rank the relative importance of factor perceived by an engineer, project manager, architect and contractor to factors influencing NZEB. The outcomes can help all practitioners to develop a wider and deeper perspective of factors and provide guidance to construction firms for efficient solutions. (Brostrom,2008) (Nogychu,2008)

II. RESEARCH OBJECTIVE

The following are the objectives of this study:

1. To identify the factor influencing Construction of NZEB through Literature review.
2. To conduct a Questionnaire Survey among the construction firms in Vadodara, Surat, Navsari and Valsad to identify the causes and rank them by Relative importance index (RII) method.

III. MAJOR FINDING FROM LITERATURE REVIEW

1. Energy utilization in commercial and residential buildings is 33-40% and up to 40-50 % worldwide of total energy utilizes, and anticipated to an upswing in the near future. (charron,2005)(Hui,2010)
2. The utilization of natural ventilation in dense, polluted and noisy urban city may present an important technical challenge. For sustainable development and energy efficiency, net zero energy building is especially vital.(Heunze,2009) (Kahoorzadeh,2014)
3. A cost ZEB is the most troublesome ZEB objective to achieve as a result of typical commercial rate structures, training, and awareness, lack of community design standards, government, energy efficiency, renewable energy, and the environment.(Kim,2015)(Vu,2010)
4. That homes with near net-zero energy consumption can be designed in a cost-effective manner, Net-zero energy buildings are an exciting next step. (Srinivasan,2011)
5. Renewable energy balance buildings promote a high standard of sustainability by optimizing the use of renewable energy and materials over the entire life-cycle of the building. (Chhetri,2015)
6. A Total energy saving of 18-25% in annual need can be obtained by employing Passive Solar Design strategies. PV and solar collectors reduce in energy compared to a typical home is 75%. (Kolokotsa,2011)
7. NZEB will play an increasingly important role in sustainable Development. To enhance, more works in these areas are required life-cycle cost and environmental impact analysis, climate change, and social policy issues.

IV. QUESTIONNAIRE DESIGN

The questionnaire design took into the consideration the objectives of the study with the aim to answer the research question. The Research questions were referred from the literature, and finalized with the help of the most experienced professionals, helps to identify the right questions required and present them in a clear format and also Special care was done for phrasing the questions that are easily understood by the respondents. A content involved in the questionnaire was divided into two major sections. The initial part is about general information about the respondent, such as (1) Name, (2) Designation of the respondent, (3) Year of experience, (4) Contact address, and furthermore respondents were asked about factor influencing adoption of NZEB in a construction firm. A 6-point Likert scale was used to understand the perception of practitioners as 1. representing No impact, 2. Very Less impact, 3 Less impact 4. Moderate impact, 5. High impact, 6. Very high impact as indicated by the degree.

V. RESEARCH METHODOLOGY

The research methodology for this study has adopted questionnaire survey to identify factors influencing the construction of NZEB in Gujarat region. To identify NZEB factors, literature reviews, discussion with experts were carried out. From the existing literature on the construction industry, it was possible to identify certain major effects. A questionnaire was then drawn up. As the outcome of the review 41 factors of cost overrun were identified. These questionnaires were distributed to Engineer, Project Manager, Architect, and Contractors of a construction firm. The data from the questionnaire was analyzed using Microsoft excel. The perspective of the respondent has been analyzed to rank the factors based on their Relative important index. Relative important index method was used for hierarchal assessment of factors and found out the top most significant factors of cost overruns.

The questionnaire was designed so that it is easy to read and responses are easy to fill in. A Likert scale of measurement will be applied for data measurement in the questionnaire survey. These sections were designed to obtain the responses on a Likert scale that indicates the relative importance of various factors. Ordinal scale use in this study involve Very high impact (V.H), High impact (H.I) ,Moderate impact (M.I) ,Less impact (L.I),Very less impact (V.L.I),No impact (N.I) . However, abbreviation replaces with numbers i.e 1 for No impact; 2 for Very less impact; 3 for Less impact; 4 for moderately impact; 5 for High impact and 6 for very significant. This will be adopted to understand the perception of personnel of the respondent involved in construction projects. The questionnaire has been given personally to the respondents and communicated to fill without hesitation or with no bias. In the study Relative Important index (RII) have been employed and calculated for ranking of factor affecting NZEB in the construction project. The RII is used to rank the different factors. These rankings make it possible to cross-compare the relative importance of the factors as perceived by the two groups of respondents. All the numerical scores of each of the identified factors were transformed to relative importance indices to determine the relative ranking of the factors. Higher the value of RII, more important is the factor affecting NZEB construction in the Gujarat region.

VI. DATA COLLECTION

Engineer, Project manager, Architect and Contractors of this Gujarat region were targeted for the survey. The details of various firms and their contacts were obtained through the internet and personal references. 62 samples of responses were to be collected from Engineer, Architect, Project manager, and Contractors. As the response rate is very low, the questionnaire was distributed to the various parties more than the sample size requirement. A total of 122 questionnaires were distributed to different respondents in Vadodara, Surat, Navsari and Valsad. The response rate was slow and timely reminders were also required. This study has so far received 98 responses. This was more than the required sample size. The Table-1 and figure-1 shows a stakeholder wise response rate as follows

Table-1 Stakeholder Wise Response Rate

Stakeholder	Targeted Sample Size	Response Received	No Response	Response Rate (%)
Contractors	40	33	7	82.52
Project Managers	22	16	6	72.80
Architect	15	9	6	60.00
Engineers	45	40	5	88.89
Total	122	98	24	76.03

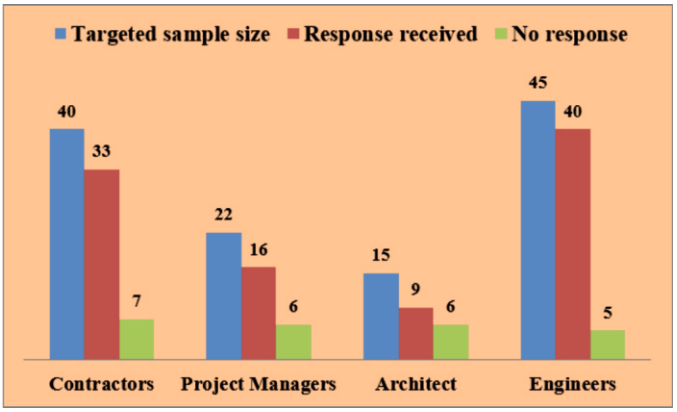

Figure-1 Stakeholder wise response rate

VII. DATA ANALYSIS

Relative Importance Index Technique

Relative Importance Index method to determine the relative importance of the various factors among various parties. The Six-point Likert scale was adopted and it ranged from 1 (No impact) to 6 (Very high impact). This was transformed to Relative Importance Indices (RII) for each factor as follows: (Li,2013)

$$RII = \frac{\sum W}{A \times N} \quad \text{.....(eq.1)}$$

Where W is the weighting given to each factor by the respondents (ranging from 1 to 6), A is the highest weight (i.e, 6 in this case), and N is the total number of respondents. The RII value had a range from 1 to 6 and higher the value of RII, more important was the cause of delays. The RII rankings made it possible to cross compare the relative importance of the factors as perceived by the four groups of respondents (i.e., Engineer, Architect,Project manager, and Contractors). Each individual cause's RII perceived by all respondents should be used to assess the general and overall rankings in order to give an overall picture of the factor affecting NZEB in Gujarat region, India.

The ranking of factors has been done based on the relative important index (RII) value calculated for each group of respondent i.e. Engineer, Architect,Project manager and Contractor) and also the overall respondents. Appendix-1 shows RII ranking of factors provided from Contractor, Architect, Project manager and Engineers. The table 2 shows the top most significant factor influencing NZEB, their RII value and rank obtain from overall respondents.

Table-2 The top most significant factor of NZEB ranked by overall respondents

Id.no	Factor	RII	Rank
20	Financing	0.94	1
39	Subsidies	0.94	2
33	Building orientation	0.92	3
36	Passive solar design	0.91	4
3	Peak electricity demand	0.91	5
24	Solar panel cost	0.91	6
15	Thermal comfort	0.90	7
29	Lack of energy conservation code	0.89	8
35	Appropriate system size	0.88	9
34	Building envelope	0.88	10

From the analysis of results, it was found that financing, Subsidies, Building orientation, Passive solar design, Peak electricity demand, Solar panel cost, Thermal comfort, Lack of energy conservation code, Appropriate system size, Building envelope are ranked high by respondent. These most significant factors discuss in more detail as follows provided by the Engineer, Project manager, Architect and Contractor.

Financing: Construction undertakings are, by and large, costly speculations for office proprietors. A constructed facility is a long-term cost benefit only over long-term use-creating a circumstance where numerous participants don't have the assets to completely pay off a project in one lump sum. To manage financing problem to participants appropriate planning of advance energy conservative resources should be done in the early stage to completion stage to minimize total cost.

Subsidies: A subsidy is a benefit given by the legislature to gatherings or individuals, more often in the form of a cash payment or a tax reduction. The subsidy is typically given to remove some type of burden, and it is often considered to be in the overall interest of the public. Construction participants like to get advantage of subsidies to reduce the overall cost for achieving net zero energy in the building environment.

Building orientation: Orientation, layout, and location on the site will all influence the amount of sun a building receives and therefore its year-round temperatures and comfort. For maximum solar gain, a building will be located, oriented and designed to maximize window area facing north (or within 20 degrees of north) – for example, a shallow east-west floor plan.

Passive solar design: The key to designing a passive solar building is to best take advantage of the local climate performing an accurate site analysis. Elements to be considered include window placement and size, and glazing type, thermal insulation, thermal mass, and shading. Passive solar design techniques can be applied more easily to new buildings, but existing buildings can be adapted or "retrofitted".

Peak electricity demand: Energy usage during peak energy consumption period decides which type of renewable energy supply system and size of the system should adopt into building environment. Peak consumption of energy can be optimize using advance building planning in design stage and energy efficient appliances installation.

Solar panel cost: In India, for achieving NZE building mainly depend on solar energy, high quality, and energy efficient panel can help in achieving NZE goal. The government provides subsidies to encourage the use of the panel. Also reliable, efficient and cost effecting material need to research.

Thermal comfort: Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation. Maintaining this standard of thermal comfort for occupants of buildings or other enclosures is one of the important goals of HVAC (heating, ventilation, and air conditioning) design engineers.

Lack of energy conservation code: Building energy codes are one path in which architects can assume greater control over the impact of the buildings they design. Code compliance is a mandatory requirement for buildings; architects have the opportunity to increase their influence by using the energy code to take ownership of building performance.

Appropriate system size: A space prerequisite essential part in accomplishing net zero energy stage in the building. For the implementation of renewable energy sources and energy efficient, adequate size must be accessible.

Building envelope: The building envelope is the interface between the inside of the building and the outside environment, including the walls, roof, and the establishment. By acting as a thermal obstruction, the building envelope assume a critical part in directing inside temperatures. Minimizing heat transfer through the building envelope is crucial for reducing the need for space heating and cooling.

VIII. CONCLUSION

The present study distinguished and analyzed factor influencing NZEB in the construction sector in Gujarat region. It was observed from the factor for NZEB are Financing, Subsidies, Building orientation, Passive solar design, Peak electricity demand, Solar panel cost, Thermal comfort to users. For the effective and proficient development of NZE of construction projects, the author recommends that material management, proper financial management, adequate building design planning and advance energy-saving equipment and materials may be adopted.

An endeavor is made to capture the factor that best clarifies the occurrence and non-occurrence of energy efficiency and energy conservation in NZE in the construction sector. The statistical method could assist the decision makers in recognizing factor influencing NZEB.

APPENDIX-I

Table-3 RII Ranking of factor influencing NZEB

Sr. No.	Factors	Engineer	Rank	Project manager	Rank	Architect	Rank	Contractor	Rank
1.	Annual energy consumption	0.683	28	0.604	31	0.685	29	0.682	29
2.	Renewable Energy implementation	0.417	40	0.469	39	0.630	33	0.495	36
3.	Peak electricity demand	0.950	3	0.896	13	0.907	9	0.899	4
4.	Embodied energy strategy	0.879	14	0.865	19	0.907	9	0.692	27
5.	A sustainable material	0.850	19	0.854	22	0.852	18	0.879	6
6.	Durability	0.583	31	0.865	19	0.704	28	0.808	18
7.	Material efficiency	0.767	23	0.906	8	0.722	26	0.823	15
8.	Adaptability	0.558	33	0.531	36	0.463	38	0.571	35
9.	Service provider	0.888	11	0.760	26	0.852	18	0.934	2
10.	Geothermal heat pump	0.763	24	0.740	27	0.722	26	0.672	30
11.	Rainwater harvesting	0.704	26	0.771	24	0.778	25	0.596	33
12.	Grey Water Recycling	0.508	36	0.552	34	0.500	37	0.596	33
13.	GHG emissions	0.908	10	0.896	13	0.889	11	0.808	18
14.	Indoor air quality	0.704	26	0.781	23	0.796	22	0.828	14
15.	Thermal comfort	0.913	9	0.885	17	0.963	1	0.843	12
16.	Ventilation	0.879	14	0.875	18	0.870	15	0.848	10
17.	Daylighting	0.929	6	0.583	33	0.944	2	0.813	16
18.	Noise	0.563	32	0.625	30	0.463	38	0.389	41
19.	Water quality	0.621	29	0.552	34	0.574	35	0.455	38
20.	Financing	0.942	4	0.969	1	0.944	2	0.924	3
21.	Marketability	0.550	35	0.510	38	0.685	29	0.712	25
22.	Initial cost	0.846	21	0.906	8	0.889	11	0.788	21
23.	Electricity Transaction cost	0.883	13	0.865	19	0.815	20	0.813	16
24.	Solar panel cost	0.938	5	0.917	6	0.926	6	0.869	8
25.	Maintenance cost	0.754	25	0.771	24	0.796	22	0.753	24
26.	Site Suitability	0.454	39	0.469	39	0.685	29	0.409	40
27.	Local rules & regulation	0.808	22	0.896	13	0.815	20	0.758	23
28.	Rules for selling electricity	0.879	14	0.958	2	0.796	22	0.808	18
29.	Safety code	0.921	7	0.938	3	0.870	15	0.859	9
30.	Electricity metering	0.850	19	0.917	6	0.889	11	0.848	10
31.	Tax policies	0.492	38	0.427	41	0.444	41	0.429	39
32.	Lack of enforcement	0.500	37	0.531	36	0.463	38	0.495	36
33.	Building orientation	0.921	7	0.906	8	0.944	2	0.899	4
34.	Building envelope	0.888	11	0.927	4	0.926	6	0.783	22
35.	Appropriate system size	0.879	14	0.896	13	0.870	15	0.879	6
36.	Passive solar design	0.958	2	0.906	8	0.944	2	0.843	12
37.	Electricity selling price	0.608	30	0.594	32	0.574	35	0.601	32
38.	Renewable energy certificate	0.879	14	0.927	4	0.926	6	0.707	26
39.	Subsidies	0.975	1	0.906	8	0.889	11	0.980	1
40.	Profit from selling electricity	0.558	33	0.729	28	0.611	34	0.687	28
41.	Insufficient training	0.563	32	0.656	29	0.667	32	0.662	31

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